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IS 14307-1 to 4 (1995): Shipbuilding - Deck Covering, Thermal and Acoustic Insulation Materials - Methods of Tests : Part 1 Toxicity index, Part 2 Smoke Index, Part 3 Non-combustibility and, Part 4: Flame penetration [TED 17: Shipbuilding]



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पोत निर्माण — डेक आवरण, ताप और ध्वनि रोधन
सामग्रियाँ — परीक्षण पद्धतियाँ

Indian Standard

SHIPBUILDING—DECK COVERING, THERMAL
AND ACOUSTIC INSULATION MATERIALS—
METHODS OF TESTS

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Shipbuilding Sectional Committee had been approved by the Transport Engineering Division Council.

During development of deck coverings, thermal and acoustic insulation material specifications the committee felt that the standardization of test methods and procedures was inadequate for many requirements specific to shipbuilding for which neither Indian Standards nor International Standards were available. Thus, a set of four standards on test methods dealing exclusively for testing insulating materials were evolved. The test methods meet the stipulations of International Maritime Organization (IMO), Statutory Bodies and Classification Societies. This set of standards is now being issued under a single Indian Standard in four parts as under:

Shipbuilding — Deck covering, thermal and acoustic insulation materials — Methods of tests :

Part 1 Toxicity Index

Part 2 Smoke Index

Part 3 Non-combustibility

Part 4 Flame penetration

While formulating various parts of this standard assistance has been derived from Naval Specifications, Resolution A.472 (XII) of International Maritime Organization and ISO 3261 : 1975 'Fire tests — Vocabulary' for framing the definitions.

Requirements and method of test for non-combustibility are based on the test method and requirements stipulated in IMO Resolution A.472 (XII). Working drawings of the apparatus may be obtained from the IMO Secretariat, London, if required.

This Indian Standard is one of a series of standards on test methods for deck covering, thermal and acoustic insulation materials. The other related standards are as follows:

<i>IS No.</i>	<i>Title</i>
3346 : 1980	Method for the determination of thermal conductivity of thermal insulation materials (two slab guarded hot-plate method) (<i>first revision</i>)
11239 (Part 2) : 1985	Method of test for cellular thermal insulation materials : Part 2 Dimensional stability
11239 (Part 4) : 1985	Method of test for cellular thermal insulation materials : Part 4 Water vapour transmission rate
11239 (Part 5) : 1985	Method of test for cellular thermal insulation materials : Part 5 Volume percent of open and closed cells
11239 (Part 11) : 1985	Method of test for cellular thermal insulation materials : Part 11 Compressive strength
11239 (Part 12) : 1988	Method of test for cellular thermal insulation materials : Part 12 Horizontal burning characteristics
11239 (Part 14) : 1992	Method of test for cellular thermal insulation materials : Part 14 Determination of flammability by oxygen index
13286 : 1992	Surface spread of flame for thermal insulation materials — Methods of test

The committee responsible for the preparation of this standard is given in Annex B.

In reporting the results of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'.

Indian Standard

SHIPBUILDING — DECK COVERING, THERMAL AND ACOUSTIC INSULATION MATERIALS — METHODS OF TESTS

PART 1 TOXICITY INDEX**1 SCOPE**

This standard lays down the method of test for determination of toxicity index of the deck covering, thermal and acoustic materials used in ships.

2 DEFINITION

For the purpose of this specification the following definition shall apply.

2.1 Toxicity Index

The numerical summation of the toxicity factors of selected gases produced by complete combustion of the material in air under the conditions specified. The toxicity factors are derived from the calculated quantity of each gas that would be produced when 100 g of the material is burnt in air in a volume of 1 m³ and the resulting concentration expressed as a factor of the concentration fatal to man at a 30 min exposure time (*see A-3*). An index of 1 for a given volume will, on average, bring about death in 30 min.

3 PRINCIPLE

3.1 Analytical data of certain small molecular gaseous species arising from the complete combustion under flaming conditions of the material under test are mathematically computed, using the exposure level (in ppm) of each gas to produce fatality in 30 min as a base, to derive a combined toxicity index.

4 APPARATUS**4.1 General**

4.1.1 As far as is possible, all items of equipment within the test chamber are to be constructed of, or coated with, an inter non-metallic material.

4.1.2 The chamber is to consist of an airtight enclosure of at least 0.7 m³ volume lined with opaque plastic sheeting having a hinged or sliding door, fitted with a transparent plastic panel.

4.1.3 Some gaseous products of combustion may react with or be absorbed on the walls of the chamber. The materials of construction shall be chosen to minimize this. A lining of polypropylene has been found satisfactory, with polycarbonate where transparency is required.

4.1.4 The chamber is to be fitted with a forced air extraction system which can be closed at the exit

from the chamber when required.

4.1.5 The chamber is to be fitted with sampling positions, such that the airtightness of the chamber is not impaired (*see 4.6.1*).

4.1.6 The chamber is to contain a mixing fan capable of being switched on and off externally. A six-bladed axial fan of at least 200 mm diameter is to be mounted horizontally and centrally inside the chamber at room level to ensure rapid mixing of combustion products.

4.2 Burner

4.2.1 The burner is to be capable of achieving a flame approximately 100 mm in height and having a temperature of $1\,150^{\circ}\text{C} \pm 50^{\circ}\text{C}$ at its hottest point. A Bunsen burner operating on natural (methane) gas having a gross calorific value of approximately 40 MJ/m³ and modified to provide an external supply of air connected to the burner collar is to be used.

4.2.2 In order to achieve the flame characteristics stated in 4.2.1, a Bunsen burner of 125 mm overall height 11 mm bore burner tube and 5 mm bore gas and air inlet tubes are recommended. Gas and air flow rates of 10 and 15 litres per minute respectively satisfy the requirements, but some adjustment of the flow rates may be necessary to suit particular situations.

4.2.3 Provision is to be made for igniting and extinguishing the burner from outside the chamber using a small pilot flame on a separate gas supply.

4.2.4 Unsatisfactory results will be obtained using a conventional Bunsen burner drawing air from within the chamber. The effect is oxygen depletion and a consequential reduction of burner flame temperature, or even extinguishment, during the combustion period of a test causing loss of standard conditions.

4.3 Specimen Support

4.3.1 A device is to be provided capable of supporting the test specimen over the Bunsen without significantly masking it from the flame.

4.3.2 The support is to be an annulus cut from a non-combustible material such as sheet steel nominal thickness 2 to 4 mm of approximately 100 mm overall diameter with a 75 mm diameter hole carrying temperature resistant wires approximately 10 mm

apart to form a lattice. The complete assembly is to be equipped with a non-combustible side support arm to give a 'tennis racket' appearance.

4.4 Timing Device

4.4.1 The timing device is to be capable of measuring periods up to 5 min to an accuracy within ± 1 s.

4.5 Analytical Equipment

4.5.1 Any analytical system may be used which will allow rapid detection and estimation of those gases in the products of combustion detailed in Annex A. The use of colorimetric gas reaction tubes, is acceptable.

4.6 Gas Sampling

4.6.1 In order to minimize losses of certain toxic products through absorption or condensation prior to measurement, it is recommended that all sampling lines be as short as possible. This may be conveniently achieved, where use is made of colorimetric gas reaction tubes for analysis by siting the tubes within the chamber itself.

5 TEST SPECIMENS

5.1 Number and Size

A sufficient number of specimens (normally 3) are to be cut from the material under test. The mass of the test specimen is to be chosen to provide optimum analytical precision, dependent on the nature of the combustion products and sensitivity of the analytical procedure. The size and shape of the specimen are to be such that it is entirely engulfed in the flame during the test.

NOTE — In some instances, for example, highly fluorinated polymers, it will be necessary to reduce the mass of test specimens to < 0.1 g in order to achieve a concentration within the range of the currently available colorimetric gas reaction tubes for hydrogen fluoride.

5.2 Conditions

Unless otherwise stated the test specimens are to be conditioned at $23 \pm 2^\circ\text{C}$ and 50 ± 5 percent RH for 24 h before testing.

6 DETERMINATION OF BACKGROUND CORRECTION FACTOR

6.1 Position the burner in the centre of the test chamber floor, ignite it and adjust the flow rates of gas and air to achieve the flame condition described in 4.1.3 and 4.2.2. Record or otherwise control the flow rates in order that the conditions may be re-established when required. Extinguish the burner and ventilate the chamber.

6.2 Place carbon monoxide, and oxides of nitrogen tubes in position, if this method of analysis has been adopted, ensuring that all other sampling positions are sealed.

6.3 Seal the chamber, then ignite the burner, simultaneously starting the timing device. Maintain

these conditions for one minute, then extinguish the flame and start mixing fan, allowing this to continue for 30 s.

6.4 Using their respective sampling points, extract portions of the atmosphere from the test chamber to determine the concentrations of carbon monoxide, carbon dioxide and oxides of nitrogen.

6.5 Operate the extraction system of the test chamber, and open the test chamber to free air and evacuate for 3 min. Repeat the procedure from 6.1 to 6.4, but maintain the burning conditions stated in 6.3 for 2 min and 3 min in separate determinations.

6.6 The results obtained are graphically displayed to show the rate of build up of carbon monoxide, carbon dioxide and oxides of nitrogen with time of burning due to the burner alone. Zero time may be shown as 0.03 percent carbon dioxide and nil for carbon monoxide and oxides of nitrogen.

7 SAFETY OF OPERATORS

7.1 When the toxicity index test is being carried out, there is a risk that flammable and/or toxic fumes will be given off from the specimen under test. Operators are to take appropriate precautions to avoid exposure to the evolved fumes.

8 TEST PROCEDURE

8.1 Ensure that the air temperature is $23 \pm 2^\circ\text{C}$.

8.2 Select a test specimen and determine its mass to the nearest milligram.

8.3 Position the burner in the centre of the test chamber floor and establish the flame conditions described in 4.2.1. Extinguish the burner.

8.4 Place the test specimen on the support approximately in the centre of the test chamber floor and adjust the support height so that specimen will be sited within the flame boundary and subjected to the temperature given in 4.2.1.

8.5 For materials which are liable to melt and drip, test specimens may be supported on a thin bed of glass wool placed on the wire mesh sample support to prevent sample losses during the combustion.

NOTE — The glass wool found suitable for this purpose is that commonly employed as a filter membrane by analytical laboratories.

8.6 Ensure that the forced extraction ventilation system is off and sealed from the chamber.

8.7 Insert series of colorimetric gas reaction tubes into the chamber.

8.8 Close the test chamber access door, turn on the fuel supply to the burner and ignite simultaneously and start the timing device.

8.9 The burn period is to be continued for the duration considered sufficient to ensure complete combustion of the whole specimen, and this is to be recorded and the burner extinguished.

8.10 Start the mixing fan and continue mixing for 30 s, then switch off fan.

8.11 Immediately commence sampling the atmosphere from the chamber by drawing the gas mixture through each respective detection tube in turn. It is imperative that if the presence of halogen acids is suspected, then these must be tested for before other gases, in order to reduce losses through absorption or condensation which may be experienced through a delayed estimation.

8.12 On completion of the analysis, the remaining products of combustion are removed from the chamber using the forced extraction exhaust system, initially opening the access door. Continue the forced ventilation for at least 3 min.

8.13 Examine the residue of the test specimen to ensure that all of the combustible material has been consumed. If any portion remains unburnt or appears to be, the whole test shall be repeated using a fresh sample.

8.14 Repeat 8.1 to 8.13 with a fresh specimen to obtain a duplicate determination, for as many times as necessary (see 5.1).

9 CALCULATION

9.1 Using the graph prepared as described in 6, determine the quantity of carbon monoxide, carbon dioxide and oxides of nitrogen formed by the burner in the time recorded in 8.9. Subtract these values from the total carbon monoxide, carbon dioxide and oxides of nitrogen contents determined by analysis (see 8.11) to give the amounts actually produced by combustion of the test specimen.

9.2 Using the formula given below, calculate the concentration of each gas produced when 100 g of material is burnt and the combustion products diffused in air in a volume of 1 m³ (C_g):

$$C_g = \frac{C \times 100 \times V}{m} \text{ ppm}$$

where

C = concentration of gas in test chamber (ppm),

m = fire test mass (g), and

V = volume of test chamber (m³).

Calculate C_g for each gas in the duplicate determination.

Average the values of C_g for each gas.

9.3 Calculate the Toxicity Index as follows:

$$\text{Toxicity Index} = \frac{C_{g1}}{C_{f1}} + \frac{C_{g2}}{C_{f2}} + \frac{C_{g3}}{C_{f3}} + \frac{C_{gn}}{C_{fn}}$$

where

1, 2, 3.....n represents each of the gases, and

C_f = concentration of the gas considered fatal to mass for a 30 min exposure time (ppm).

Values of C_f for various gases are given in Annex A.

10 REPORT

10.1 The report is to include the following :

- A full description of the material tested, including type, grade, reference No., etc;
- The Toxicity Index per 100 g material; and
- The following statement :

This test result alone does not assess the fire hazard of the material, or a product made from this material, under actual fire conditions. Consequently, the results of this test alone are not to be quoted in support of claims with respect to the fire hazard of the material or product under actual fire conditions. The results when used alone are only to be used for research and development, quality control and material specifications.

ANNEX A

(*Clauses 2.1, 4.5.1 and 9.3*)

A-1 TOXIC CONSTITUENTS

The analysis of the products of combustion in the test chamber is to include the quantitative determination of the following gases :

Carbon dioxide	(CO_2)
Carbon monoxide	(CO)
Formaldehyde	(HCHO)
Nitrogen oxide	($\text{NO} + \text{NO}_2$)
Hydrogen cyanide	(HCN)
Acrylonitrile	(CH_2CHCN)
Phosgene	(COCl_2)
Sulphur dioxide	(SO_2)
Hydrogen sulphide	(H_2S)
Hydrogen chloride	(HCl)
Ammonia	(NH_3)
Hydrogen fluoride	(HF)
Hydrogen bromide	(HBr)
Phenol	($\text{C}_6\text{H}_5\text{OH}$)

The above list is not intended to be a complete list of all possible gases that may be found in the products of combustion but it does represent those most commonly produced in quantity upon which toxicity data may be based.

A-2 ANALYSIS

It is obvious that there is no need to determine the quantity of, say, hydrogen chloride in the products of combustion if the material being tested does not

contain chlorine (chloride). Therefore, as an aid to analysis it is desirable to determine the elements present in the material before an assessment of the Toxicity Index is carried out, for example, if no nitrogen is found then there is not need to analyse for nitrogen containing gases, that is, nitrogen oxides, hydrogen cyanide, acrylonitrile and ammonia.

A-3 TOXICITY CONCENTRATIONS (ppm)

For the purposes of calculating toxicity indices, the following values of *C* are to be used :

Carbon dioxide	100 000
Carbon monoxide	4 000
Hydrogen sulphide	750
Ammonia	750
Formaldehyde	500
Hydrogen chloride	500
Acrylonitrile	400
Sulphur dioxide	400
Nitrogen oxide	250
Phenol	250
Hydrogen cyanide	150
Hydrogen bromide	150
Hydrogen fluoride	100
Phosgene	25

Indian Standard

SHIPBUILDING — DECK COVERING, THERMAL AND ACOUSTIC INSULATION MATERIALS — METHODS OF TESTS

PART 2 SMOKE INDEX

1 SCOPE

This Indian Standard lays down the method of test for determination of smoke index of the deck covering, thermal and acoustic materials used in ships.

2 APPLICATION

The method has been found suitable for testing materials in the form of sheet (up to 25 mm thick) or film. It shall not be used alone for the description or appraisal of the fire hazard of a material or product under actual fire conditions.

3 PRINCIPLE

A material is exposed to specified standard thermal conditions of pyrolysis and combustion in a continuous procedure. The change in optical density of the smoke produced when dispersed within a fixed volume of air is recorded throughout the period of the test. The resulting density/time curve is used to calculate the Smoke Index.

4 DEFINITIONS

4.1 For the purpose of this standard the following definitions shall apply.

4.1.1 Combustion

Reaction of a substance with oxygen with release of heat generally accompanied by flaming and/or glowing and/or emission of smoke.

NOTE — Apart from exceptional cases the concentrations of oxygen to be considered do not exceed those normally found in air.

4.1.2 Pyrolysis

Irreversible chemical decomposition due to an increase in temperature without oxidation.

4.1.3 Smoke Index

The numerical summation of the rates of change in specific optical density of the smoke produced from the start of the test to 70 percent, 40 percent, 10 percent, etc, and minimum light transmittance values.

5 APPARATUS

5.1 Test Chamber

5.1.1 The apparatus required is known as smoke density test chamber and is briefly described as a

closed chamber approximately 900 mm high, 900 mm wide and 600 mm deep in which a specimen 75 mm x 75 mm x thickness as supplied (up to 25 mm maximum) is supported in a frame, with a face in a vertical plane, and exposed to heat and then to flame. In setting up the smoke chamber the exhaust blower outlet shall be connected by hose to an exhaust hood or vent to ensure that on completion of a test the products of combustion formed do not contaminate the laboratory atmosphere as the gases may be toxic to personnel. The material of the test chamber under test conditions should not affect the test results.

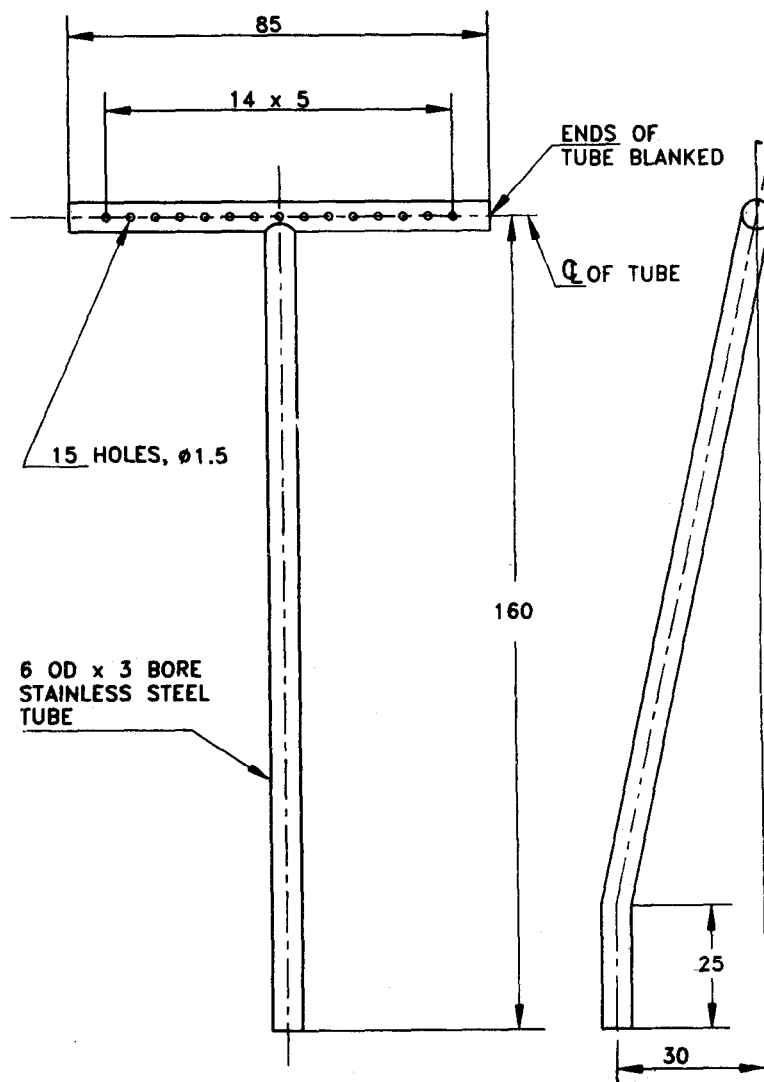
5.1.2 The heat source is an electric furnace adjusted to give a heat flux of 2.5 watts/cm² at the specimen surface. A vertical collimated light beam is employed through the full height of the chamber with a photo multiplier micro-photometer system to measure the transmittance of light.

5.1.3 The apparatus shall also be equipped with the following:

- a) *Fixing Fan* — A small fan shall be positioned centrally near the top of the chamber to ensure complete dispersion of the smoke homogeneously throughout the chamber.
- b) *Auxiliary Heater* — A small black heater is positioned centrally in the chamber and is used only to reduce the time delay in reaching operating temperature.
- c) *Burner* — A multi-jet burner constructed as shown in Fig. 1 shall be used with premixed air/natural gas fuel. The burner shall be centered in front of the specimen holder level with bottom edge of the specimen and 10 mm away from it. The air and natural gas shall be metered using calibrated rotameters, the rate being such that a blue flame is obtained which touches the specimen over 90 percent of its width at a height approximately 5 mm above its bottom edge. It shall be so arranged that the burner may be ignited remotely without having to open the chamber.

5.2 Timer

A timing device measuring intervals up to at least 20 min and accurate to within ± 1 s shall be used.



All dimensions in millimetres.

FIG. 1 DETAIL OF TYPICAL BURNER

5.3 Chart Recorder

A chart recorder, set to operate with a full scale deflection of 50 mV, is connected to the output from the micro-photometer to provide a continuous record of the percentage change of transmittance with time during a test run.

6 TEST SPECIMENS

6.1 Sheet or Film Materials

At least 3 specimens shall be cut from the material under test. The dimensions shall be 75 mm x 75 mm utilising the natural thickness of the material except where it exceeds 25 mm, in which case the material shall be reduced in thickness to 25 mm by cutting away the face not required to be tested.

6.2 Mounting of Specimen

Cut a sheet of heavy duty aluminium foil (approx 0.04 mm thick) to a size which will permit overlapping of the sample face on all four sides by approximately 6 mm. Place the sample in the centre of the foil and fold excess over the edges and against the face to be tested. Place the wrapped sample into a sample holder so that the face to be tested is exposed. Place an insulating block against the sample, insert the tension spring and locking pin, taking care not to compress flexible samples below their normal thickness. Without cutting the face of the sample, carefully remove any exposed foil.

6.3 Conditioning

Unless otherwise agreed, all test specimens shall be conditioned at $23 \pm 2^\circ\text{C}$ and 50 ± 5 percent RH for at least 24 h prior to testing.

7 SAFETY OF OPERATORS

When the test is being carried out, there is a risk that flammable and/or toxic fumes are given off from the specimen under test. Operators are to take adequate precautions to avoid exposure to the evolved fumes.

8 PROCEDURE

8.1 These instructions relate specifically to the smoke density test chamber as modified in 5.1.3.

8.2 Switch on the power to the chamber, chart recorder, internal fan and auxiliary heater.

8.3 Ensure that the 'FLAME GAS', 'RADIOMETER AIR' and 'FLAME AIR' toggle valves are shut. Turn on gas and air supplies.

8.4 Close 'VENT' and 'INLET VENT' on the chamber.

8.5 Ensure optical shutter on the photomultiplier box is in the 'OUT' position, turn on 'LINE' and 'LAMP'.

8.6 Set the photomultiplier photometer to 'ON'.

8.7 Switch on 'HEATER' and set 'HEATER VOLTS ADJUST' control to 30 percent. After about five minutes reset to 60 percent, then to 90 percent after a further five minutes.

8.8 When a chamber wall temperature of 35°C is attained as shown on the chamber temperature meter, switch internal fan and auxiliary heater 'OFF'.

8.9 Set the photomultiplier photometer to HV.

8.10 Set the chart recorder to 50 mV full scale deflection.

8.11 Calibrate the photomultiplier photometer as follows:

- a) Clean the lower and upper optical windows with soft tissue moistened with alcohol.
- b) Set 'MULTIPLIER' switch to 0.1.
- c) Set 'BLANK ADJUST' to 'LOW'.
- d) Set 'DAMPING' to 'OFF'.
- e) Depress 'FINE ADJUST' control and rotate clockwise two full turns.
- f) Adjust the 'BLANK ADJUST FINE' control until meter indicates 0 percent relative intensity (transmittance). Set the chart recorder pen to zero.
- g) Reset 'MULTIPLIER' switch to 100 and 'DAMPING' to 'ON', depress 'FINE ADJUST' control and rotate anti-clockwise until a slight stop is reached (about 2 full turns).
- h) Open photomultiplier tube shutter by depressing the black rod on the

photomultiplier box to the 'IN' position.

- j) Depress 'FINE ADJUST' control and rotate until meter indicates 100 percent transmittance. Set the chart recorder pen to 100 percent.

8.12 Set the 'HEATER VOLTS' control to the pre-determined voltage to obtain an output of 2.5 Wcm².

8.13 Open the 'INLET VENT' and the chamber is ready for use.

8.14 After half a minute, to allow the furnace to reach the correct output, place the loaded sample holder on the support rods directly in front of the furnace.

8.15 Immediately start the chart recorder drive, shut the door of chamber and close the 'INLET VENT' (a convenient chart speed is 10 mm/min).

8.16 After five minutes open the 'FLAME GAS' and 'RADIOMETER AIR' toggle valves. Adjust the auxiliary flowmeter to give a gas flow of 500 cm³ per minute. Adjust the air input to 18 on the 'RADIOMETER AIR' flowmeter.

8.17 Operate the remote ignition device switch until the flame ignites.

8.18 Continue the run for a further 15 minutes, or until a minimum transmittance value is reached.

8.19 If at any time the transmittance value falls below 10 percent change the multiplier switch to 10; if the transmittance again falls below 10 percent of full scale, change the multiplier switch to 1. A further drop to below 10 percent of full scale will require the multiplier switch to be changed to 0.1. On completion of the test the switch shall be reset to 100 before the maximum clear beam transmittance value T_c may be obtained.

8.20 After the total time of 20 min close the 'FLAME GAS' and 'RADIOMETER AIR' toggle valves, slide the sample away from the front of the radiant panel and reduce the 'HEATER VOLTS ADJUST' control to 50 percent.

8.21 Evacuate the chamber by opening the 'VENT' and 'INLET VENT'.

NOTE — Laboratory ventilation fans shall also be run.

8.22 After complete evacuation of the chamber obtain a new maximum clear beam transmittance value on the chart recorder, this reading being designated as the value T_c .

8.23 For testing of replicates or fresh materials on the same dry restart at 8.11.

9 CALCULATION

9.1 Because of the progressive build up of deposits on the optical windows during a test run, the recorded transmittance values are artificially depressed. It is, therefore, necessary to apply a

correction to the results before calculating the Smoke Index. This is carried out by constructing a new plot of the transmittance/time relationship as described in 9.2.

9.2 Correction of Results

9.2.1 Using the trace obtained from the chart pen recorder, identify the following values:

T_c = clear beam transmittance at the end of test.

T_{Min} = minimum transmittance obtained during test.

Convert T_c and T_{Min} to equivalent specific optical density, D_{sc} and $D_{s\ Max}$.

9.2.2 The conversion of percent transmittance to specific optical density for smoke density chamber is given by:

$$\text{Specific Optical Density } (D_s) = 32 \log \frac{100}{T}$$

where T = percent transmittance.

9.2.3 Subtract D_{sc} from $D_{s\ Max}$ to obtain corrected maximum specific optical density $D_{s\ Max}$. Convert $D_{s\ Max}$ to percent transmittance and plot this value on the pen recorder chart as the corrected minimum transmittance at the same time interval as T_{Min} .

9.2.4 If D_{sc} is 3 percent or less of $D_{s\ Max}$ no further correction to pen recorder trace need be made, if more than 3 percent, correct remainder trace in the following manner when transmittances less than 70 percent have been recorded:

Convert 70 percent transmittance to specific optical density that is, correct the 70 percent transmittance point on the trace by the formula:

$$20 - [20 (D_{sc} / D_{s\ Max})]$$

Convert this value back to percent transmittance and plot at the same time interval as the uncorrected 70 percent transmittance.

9.2.5 If transmittances, less than 40 percent have been recorded, correct the 40 percent transmittance (53 specific optical density) by the formula:

$$53 - [53 (D_{sc} / D_{s\ Max})]$$

Convert this value back to percent transmittance and plot at the same time interval as the uncorrected 40 percent transmittance.

9.2.6 If transmittances less than 10 percent have been recorded, correct in the same manner as for 70 percent and 40 percent transmittances shown above.

9.2.7 Construct a new curve of transmittance/time using the corrected values of transmittance obtained.

9.2.8 The Smoke Index is calculated in the following manner :

- a) If the minimum transmittance value is greater than or equal to 70 percent

$$\text{Smoke Index} = \frac{D_s \text{ at } T_{Min}}{t_{Min}}$$

- b) If the minimum transmittance value is less than 70 percent

$$\begin{aligned} \text{Smoke Index} = & \frac{D_s \text{ at } T_{70}}{t_{70}} + \frac{D_s \text{ at } T_{40}}{t_{40}} \\ & + \frac{D_s \text{ at } T_{10}}{t_{10}} \\ & + \frac{D_s \text{ at } T_{Min}[x - T_{Min}/(x - y)]}{t_{Min}} \end{aligned}$$

where

$D_s \text{ at } T_{70}$ = specific optical density corresponding to 70 percent transmittance;

t_{70} = time (in minutes) from start of test to reach 70 percent transmittance;

t_{40} = time (in minutes) from start of test to reach 40 percent transmittance;

x = lowest transmittance reference value reached during test, that is, either 70 percent, 40 percent or 10 percent; and

y = next lower transmittance reference value to x , that is, either 40 percent, 10 percent or 0 percent.

9.2.9 The Smoke Index for a material shall be the mean of the calculated smoke indices for at least 3 replicates.

10 REPORT

10.1 The report shall include the following:

- A reference to this standard.
- A full description of the material.
- The Smoke Index of the material.
- Description of any unusual behaviour during the test, for example, melting and dripping.
- The following statement:

'This test result alone does not assess the fire hazard of the material or a product made from this material under actual fire conditions. Consequently the results of this test alone shall not be quoted in support of claims with respect to the fire hazard of the material or product under actual fire conditions. The results when used alone shall only be used for research and development, quality control and material specifications.'

Indian Standard

SHIPBUILDING — DECK COVERING, THERMAL AND ACOUSTIC INSULATION MATERIALS — METHODS OF TESTS

PART 3 NON-COMBUSTIBILITY

1 SCOPE

This Indian Standard specifies the requirements and methods of test for assessing deck covering, thermal and acoustic insulation materials as meeting the requirements for non-combustible material for marine use.

2 SAMPLING

The samples shall be sufficiently large to be representative of the material, particularly in the case of non-homogeneous materials.

3 APPARATUS

3.1 Furnace

The furnace consists principally of a tube of an alumina refractory material having a mass density of between 2 700 to 3 300 kg/m³ and a height of between 149 to 151 mm, and an inner diameter of between 74 and 76 mm and a wall thickness of between 10 to 12 mm. The foregoing shall be closely adhered to as evidence shows that the material used for the refractory furnace tube and its fabrication may influence the experimental results. The overall wall thickness with applied refractory cement to retain the electrical winding shall not exceed 13 mm. The furnace tube is provided with one or more electrical heating coils and is located within an insulated surround, completed with a top and bottom plate of marine board having a thickness of between 9 to 11 mm. To the lower end of the furnace is attached a cone-shaped air flow stabilizer 500 mm long and reducing from a 75 mm internal diameter at the top to a 9 mm internal diameter at the lower end. The stabilizer may be made of steel sheet, approximately one mm thick, and shall be finished smooth on the inside, particular attention being given to the smoothness and the tightness of the joint with the furnace which shall be provided with a refractory fibre sheet seal. The upper half height of the stabilizer shall be insulated on the outside with a layer of refractory fibrous felt having a nominal thickness of 25 mm. At the open top of the furnace a draught shield, which may be made of the same material as the stabilizer cone, shall be provided having an internal diameter of 75 mm and a height of 50 mm. The draught shield shall be insulated on the outside with a layer of the fibrous felt having a nominal thickness of 25 mm.

A general representation of the furnace is shown in Fig. 1.

3.2 Furnace Stand

The furnace is mounted on a stand with a clearance of approximately 250 mm between the floor and the lower end of the stabilizer. This clearance shall be protected against disturbance by air currents. An adequate protection may be provided by using shields around the stand to a height of approximately 550 mm from the floor.

3.3 Furnace Calibration and Control

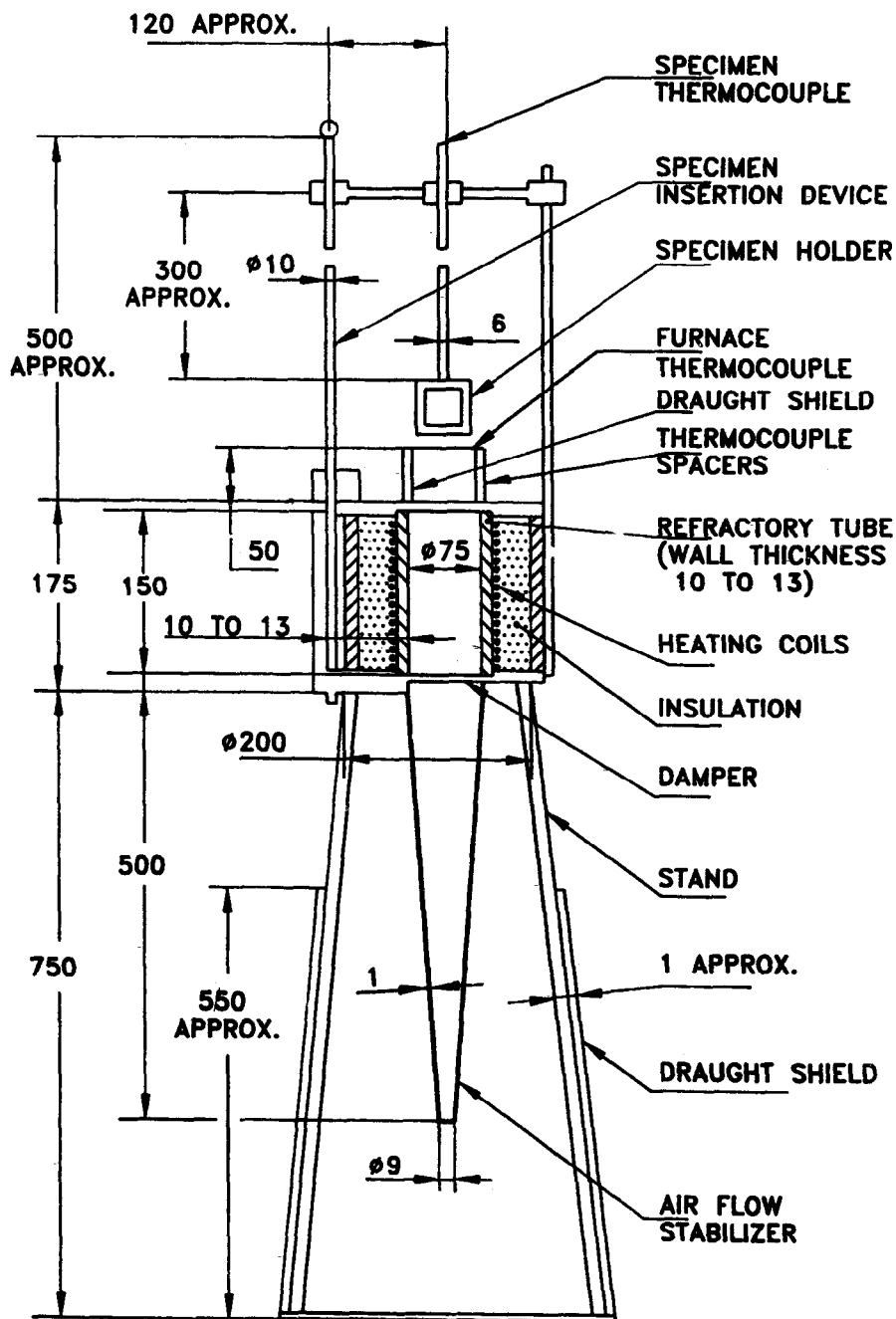
A calibrating test with the specimen basket and holder removed shall be performed on a new furnace or on an existing furnace when so required. The energy input to the furnace shall be adjusted so that the furnace thermocouple (*see* 3.5) gives a steady reading of between 740°C and 760°C. In stabilized conditions the wall temperature at the furnace shall be measured by an optical micropycrometer at intervals of 10 mm on three equally spaced vertical axes. The wall temperature shall not vary by more than 50°C over a mid-height length of 100 mm and this shall give an average wall temperature of about 850°C. This provides a constant temperature zone for the specimen and can be achieved by having the electrical windings spaces as shown on the working drawings. Separate windings may optionally be provided at each end of the furnace tube controlled independently to obtain the constant temperature zone.

To minimize temperature fluctuations in the furnace it is necessary to use a voltage stabilizer in the circuit, able to maintain voltage within ± 4 percent of the nominal value.

Automatic thermostatic control of the furnace is not to be used during test.

3.4 Temperature Measurement

Temperature shall be measured by means of insulated sheathed thermocouples having an outside diameter of between 1.4 to 1.6 mm with thermoelectric wires of approximately 0.2 mm diameter. Before using for test new thermocouples shall be aged in the heated furnace atmosphere to slightly oxidize their outer sheaths. The temperature shall be recorded by an instrument having a maximum range that corresponds with the temperature changes that occur during the tests. Measurement shall be made at intervals of not more than 10 s. The electromotive force temperature conversion process of the recording device used



All dimensions in millimetres.

FIG. 1 NON-COMBUSTIBILITY APPARATUS

shall have an accuracy of at least 0.5 percent and the thermocouples shall have a time constant in the range of 15 to 25 s. [Time constant is expressed as the time to reach 63.2 percent of the final temperature value on heating in the furnace (750°C)].

3.5 Location of Thermocouples

Three thermocouples shall be used, the furnace thermocouple to measure the furnace temperature, the surface thermocouple to measure the temperature

at the surface of the specimen and the specimen thermocouple to measure the temperature in the centre of the specimen. The furnace thermocouple shall be located with its hot junction between 9.5 and 10.5 mm from the wall of the furnace and at mid-height of the constant temperature zone as defined by the wall temperature. A method of maintaining the correct distance from the wall is by the use of a guide attached to the draught shield. The surface thermocouple shall, prior to the test, have its hot junction next to the surface of the specimen at mid-height and be in contact with the specimen. The specimen thermocouple shall be located with its hot junction in the centre of the specimen and shall be inserted from the top through a hole of 2 mm diameter. An arrangement of the empty specimen basket and thermocouples in the furnace during stabilisation prior to test is shown in Fig. 2.

3.6 Specimen Holder and Insertion Device

The specimen is placed in a basket made of nickel-chromium alloy or heat-resisting steel. At the bottom of the holder a fine metal gauze in heat-resisting steel shall be provided. The mass of the basket shall be between 5.8 g to 6.2 g. The holder is suspended from the lower end of an adjustable tube of heat-resisting steel, having an outside diameter of approximately 6 mm and a bore of 4 mm. The specimen insertion device consists essentially of a metallic sliding rod moving freely in a vertical tube fitted to the side of the furnace. The heat-resisting steel tube with the specimen holder is fixed by a space bar to the sliding rod. The design of the insertion device shall be such that the specimen can be introduced into the furnace rapidly and without any shock. The inserted specimen shall occupy a specified position in the furnace, the middle of the constant temperature zone and equidistant from the walls.

3.7 Specimen Viewing Device

A mirror shall be mounted above the furnace for observation of any evidence of flaming. It shall be mounted in such a way that it is possible to view the specimen continuously following insertion.

4 TEST SPECIMENS

4.1 Preparation of Specimens

The specimens shall be as representative as possible of the average properties of the sample and shall be prepared to the size defined in 4.2.

If the thickness of the material is less than 50 mm, the specimen shall be made of sufficient layers to achieve the thickness required in 4.2. The layers shall occupy a horizontal position and shall be held together firmly in the specimen holder. The density of the specimen shall be representative of the density of the material.

Materials or composite materials which involve thin surface laminations shall be tested without

such surface laminates unless otherwise specified by Statutory Bodies/Classification Societies.

For composite materials of a thickness such that a number of layers cannot be put together to give a specimen of the specified size as required in 4.2, the specimen shall be prepared to the required thickness by proportionally adjusting the thickness of the different components. The top and bottom faces of the specimen shall be the finished faces of the material.

If it is not possible to follow this procedure to prepare the specimen, tests shall be performed on the individual components and reported accordingly.

4.2 Number and Size

For the test purpose five cylindrical specimen shall be prepared as described in 4.1. The nominal dimensions and tolerances for the specimen sizes shall be as follows:

- diameter 43 mm to 45 mm
- height 47 mm to 53 mm
- volume 75 cm³ to 85 cm³

4.3 Conditioning

The specimens shall be conditioned in a ventilated oven maintained at between 55 to 65°C for at least 20 h and cooled to ambient temperature in a desiccator prior to the tests. The weight of each specimen shall be determined before test.

5 PROCEDURE

5.1 Apparatus

Before starting the test, it is necessary to ascertain that the whole equipment is in good working order, for example, the stabilizer cone is clean, the insertion device is working smoothly, the specimen holder occupies the exact position in the furnace and the furnace thermocouple is accurately located.

The equipment shall be protected against draughts and not be exposed to direct sunlight or artificial illumination.

The furnace with an empty specimen basket in position shall be heated and the furnace temperature stabilized at between 740 to 760°C for a minimum period of 10 min before the insertion of a specimen and during the test no adjustment shall be made in the energy input to the furnace.

5.2 Insertion of Specimen

The specimen shall be placed in the holder described in 3.6. It shall be inserted in the furnace taking not more than 5 s for this operation.

5.3 Duration of Heating

The heating period commences with the insertion of the specimen in the furnace and shall be continued for 20 minutes, or until peak temperatures have been passed.

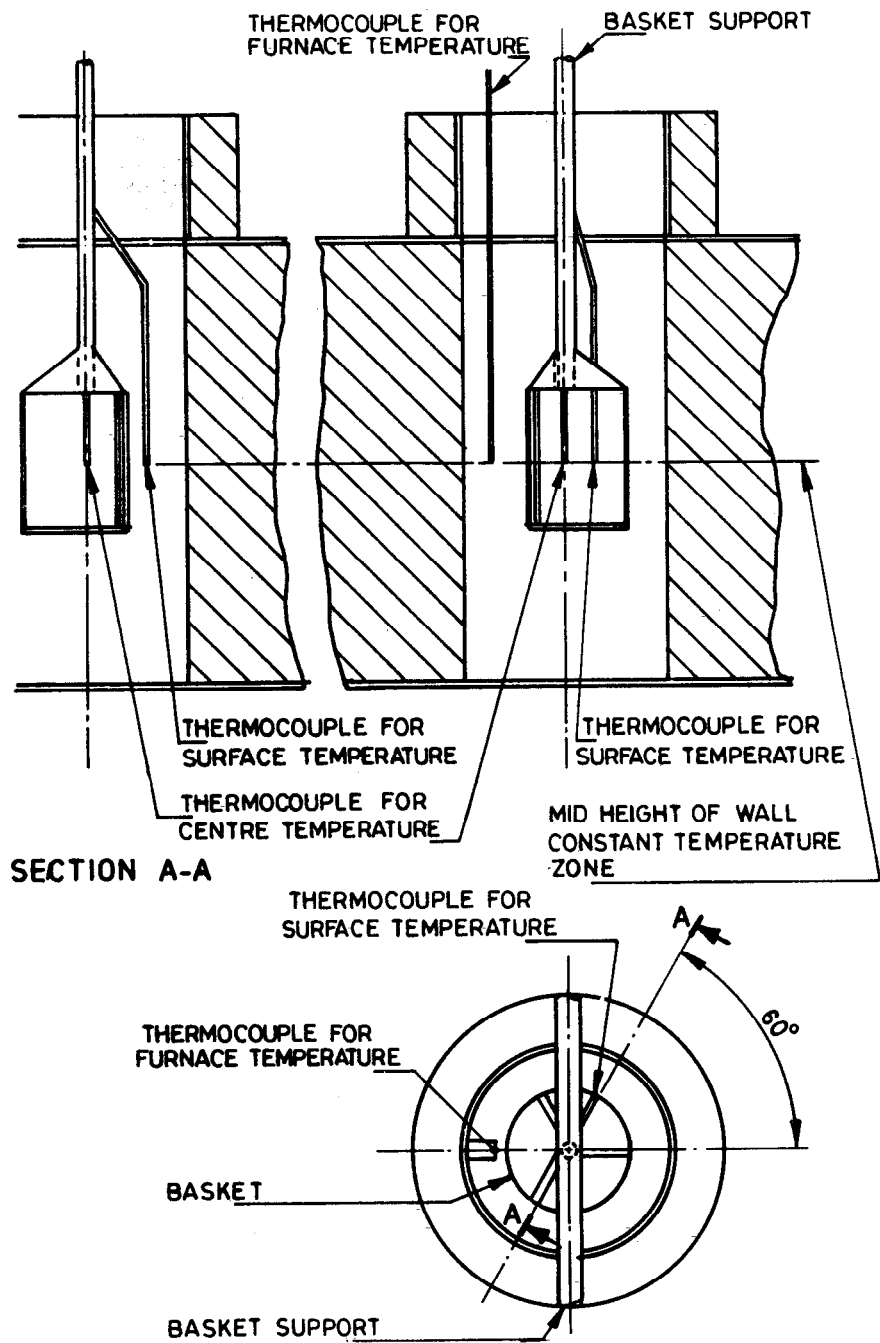


FIG. 2 ARRANGEMENT OF EMPTY SPECIMEN BASKET AND THERMOCOUPLES IN FURNACE DURING STABILIZATION PRIOR TO TEST

5.4 Test Observations

A record shall be made of the temperature readings from the three thermocouples during the heating period and note taken of the occurrence and duration of any sustained flaming. The weight of each specimen after test shall be determined. Sustained

flaming shall be taken as continuous presence of flames in the furnace.

5.5 Number of Specimens Tested

The test shall be carried out on five specimens, prepared as specified in 4.1 and 4.2.

6 CLASSIFICATION OF MATERIALS

6.1 Non-combustibility

A material shall be deemed non-combustible, if:

- a) the average of the five maximum readings of furnace thermocouples does not show a rise above the initial furnace temperature of more than 50°C [as established before inserting the specimen (*see 5.1*)];
- b) the average of the five maximum readings of surface thermocouples does not show a rise above the initial furnace temperature of more than 50°C [as established before inserting the specimen (*see 5.1*)];
- c) the average of all recorded maximum durations of sustained flaming does not exceed 10 s; and
- d) the average loss of weight for the specimens after test is not more than 50 percent of the original weight after conditioning.

6.2 Combustibility

If one of the four criteria laid down in 6.1 is not satisfied the material is deemed combustible.

7 TEST REPORT

The test report shall include the following information:

- name of testing body;
- name of manufacturer of the material;
- date of supply of the materials and of tests;
- name or identification mark of the material;
- description of the material;
- density of the material;
- description of the specimens (only for composite material);
- test method;
- test results including all temperature curves and observations; and
- designation of the material according to the test criteria specified in 6.

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Indian Standard

SHIPBUILDING — DECK COVERING, THERMAL AND ACOUSTIC INSULATION MATERIALS — METHODS OF TESTS

PART 4 FLAME PENETRATION

1 SCOPE

This Indian Standard specifies the method for determination of flame penetration for deck covering, thermal and acoustic insulation materials.

2 PRINCIPLE

The specimen is exposed to a flame by placing a filter paper between the specimen and the asbestos board. The time of flame penetration is taken from the application of the flame until the filter paper is ignited or the flame penetrates the foam.

3 APPARATUS

3.1 A propane pencil flame burner head capable to produce a temperature up to 1 100°C measured 50 mm from the head and 80 mm in length.

3.2 Timing Device

Timing device shall be accurate to ± 1 s.

3.3 An asbestos board containing a centre hole 38 mm diameter with a suitable specimen holder.

3.4 Filter Paper

4 SPECIMENS

The foam specimen shall be of 150 mm x 150 mm x 25 mm.

5 PROCEDURE

5.1 Place the specimen in the asbestos board holder.

5.2 Place a piece of filter paper between the specimen and the asbestos board covering the centre hole.

5.3 Adjust the propane pencil-flame burner head to a temperature between 1 043 to 1 071°C measured 50 mm from the burner head.

5.4 Direct the flame to the specimen and start the timing device.

5.5 The time of penetration is taken from the application of the flame until the filter paper is ignited or the propane flame penetrates the specimen.

5.5.1 Charring of filter paper is disregarded if flame is not present.

ANNEX B
(Foreword)

COMMITTEE COMPOSITION

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SHRI K. P. RAO (*Alternate*)

SHRI V. K. JAIN,

Director (Transport Engg)

Representing

Institution of Naval Architects, Bombay

Directorate of Quality Assurance (Warship Project), Ministry
of Defence, New Delhi

Garden Reach Shipbuilders & Engineers Ltd, Calcutta

Directorate General of Naval Designs, New Delhi

DGTD, New Delhi

Calcutta Port Trust, Calcutta

Indian Register of Shipping, Bombay

Small Shipowners Association, Goa

DG Shipping, Bombay

Mazagon Dock Ltd, Bombay

Ministry of Surface Transport (SBR), New Delhi

The Institute of Marine Engineers (India), Bombay

Cochin Shipyard Ltd, Cochin

Directorate of Standardization, Ministry of Defence, New Delhi

American Bureau of Shipping, Bombay

The Indian National Shipowners Association, Bombay

Goa Shipyard Ltd, Goa

Lloyd's Register of Shipping, Bombay

The Shipping Corporation of India, Bombay

Chowgule Steamships Ltd, Bombay

Flakt India Ltd, Calcutta

Oil & Natural Gas Commission, Dehra Dun

Hindustan Shipyard Ltd, Visakhapatnam

Director General, BIS (*Ex-officio Member*)

Member Secretary

SHRI N. S. JUDGE

Director (Transport Engg), BIS

(Continued on page 17)

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Deck Covering, Partitions and Insulation Subcommittee, TE 17 : 6

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SHRI A. K. SEN

Representing

The Shipping Corporation of India Ltd, Bombay

Members

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